Generic MC study of B0B0bar oscillation frequency using D*lν

1) Data Sample

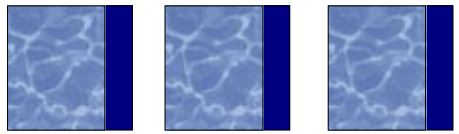
2) Reconstructing D*lν

3) Backgrounds

4) Fitting for Δm

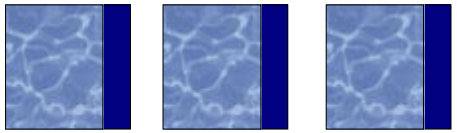
5) To Do

The purpose of this study is to develop, validate and optimize various tools for the fitting process.



1 Data Sample

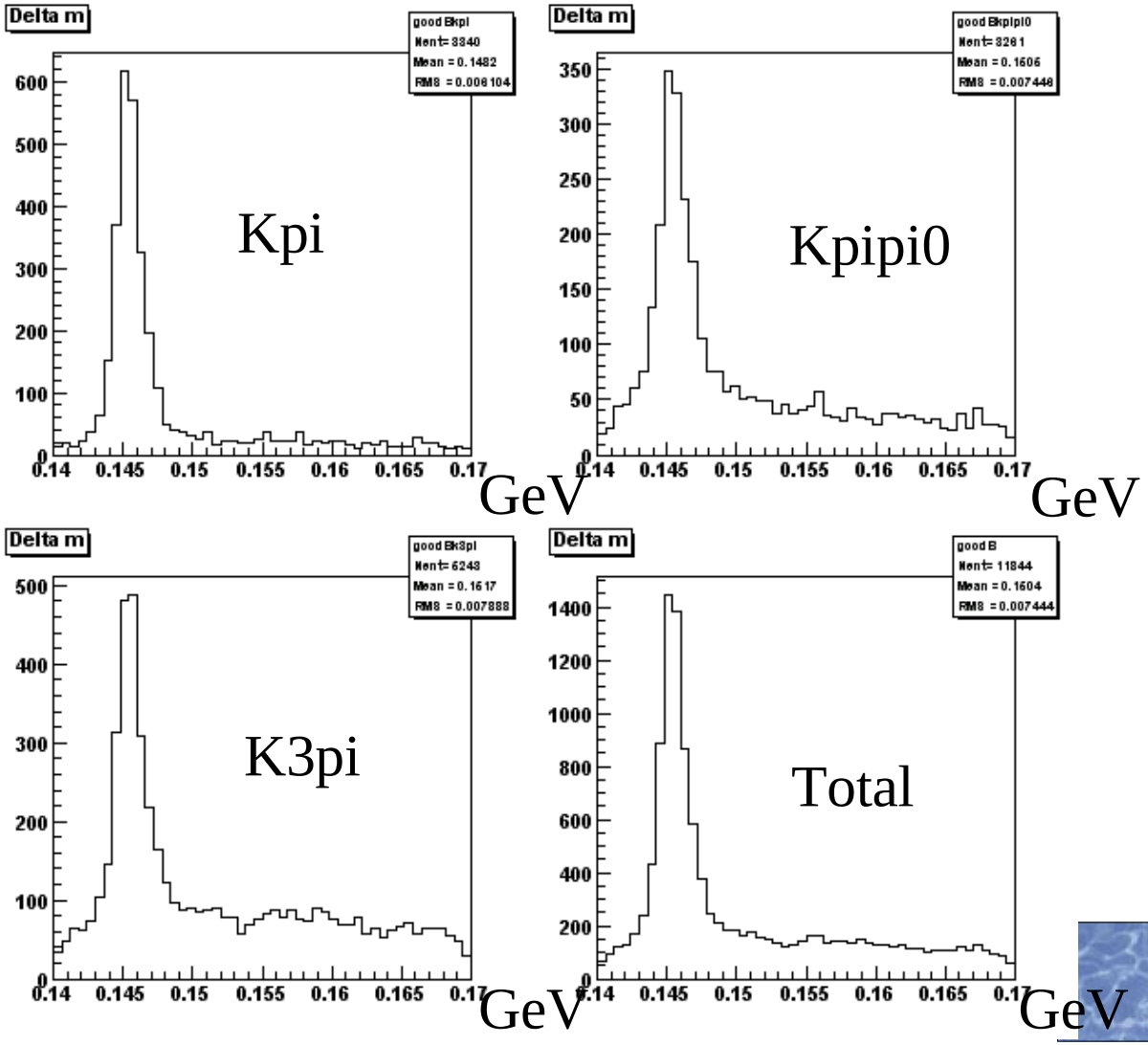
1. ~10 fb^{-1} of B0B0bar and B+B− generic MC
2. All MC from releases 8.8.0c − 8.8.0i
3. Important parameters from DECAY.DEC
   1. Dm = .472 ps^{-1}
   2. Lifetime = 1.548 ps
4. Standard DstarlnuUser ntuples are converted to root tuples and final cuts are applied. The resulting root file is similar to "ASCii" files



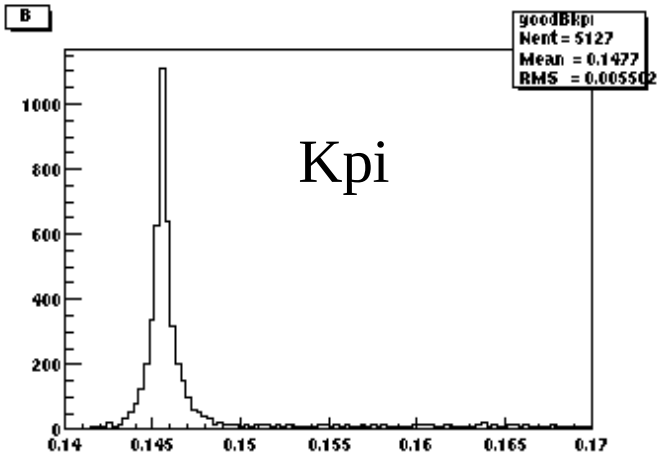
New cuts, improvements

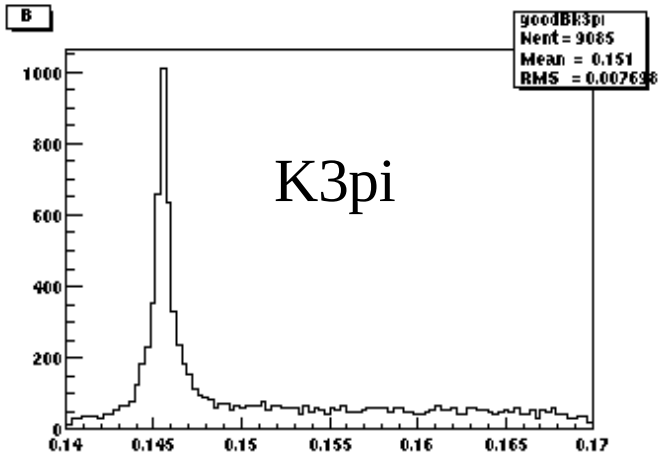
1. Very Tight lepton ID vs Tight
2. SMS Tight Kaon ID vs loose,Not a Pion for $K\pi$
3. Tighter D0 mass cut (+/− 17 Mev,34 for $K\pi\pi^0$)
4. Dalitz weight cut for $K_s\pi\pi$ and $K\pi\pi^0$ modes.
5. Deltam refitting for slow pion

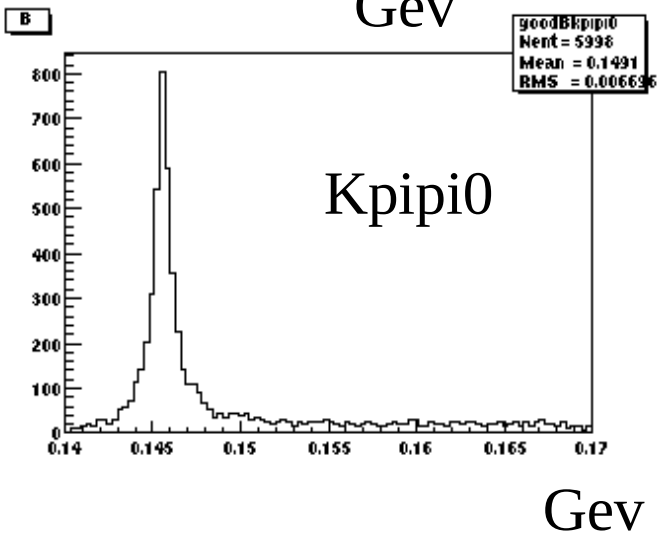
D* – D0 mass, good D*l candidates (old cuts)

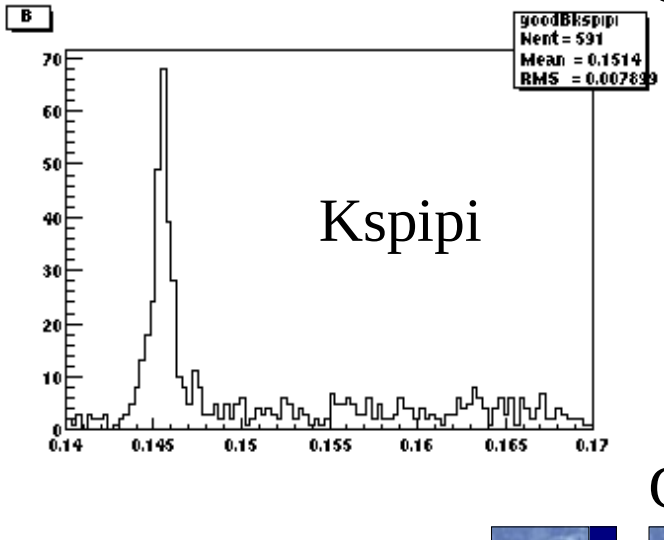


D*–D0 mass, new cuts









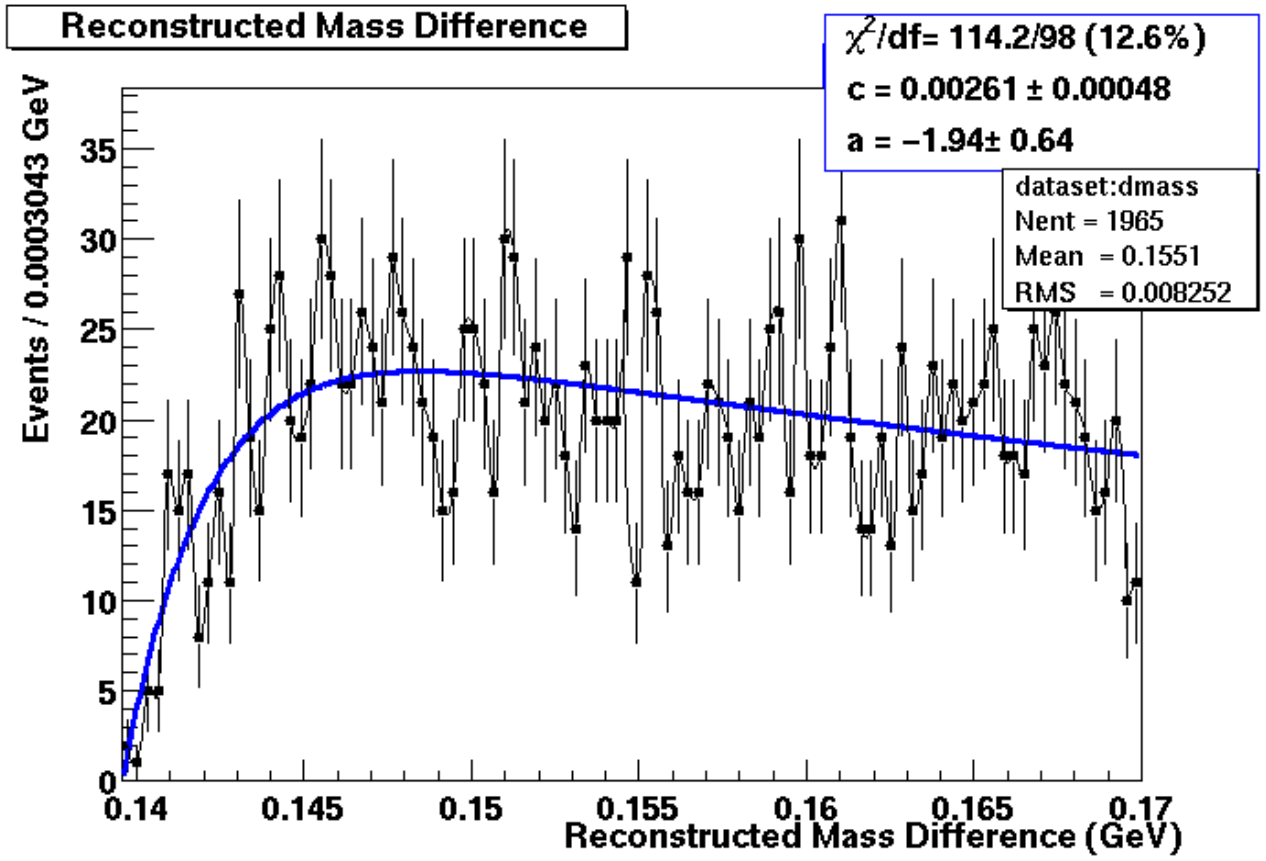
3 Backgrounds

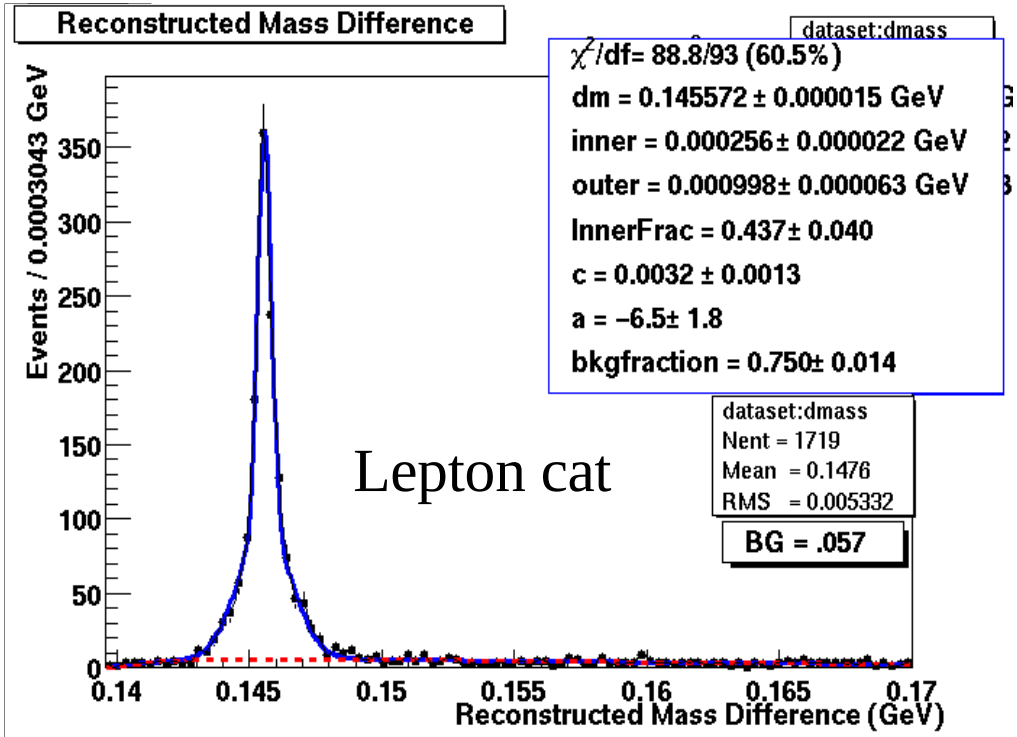
There are 5 main backgrounds we need to address:

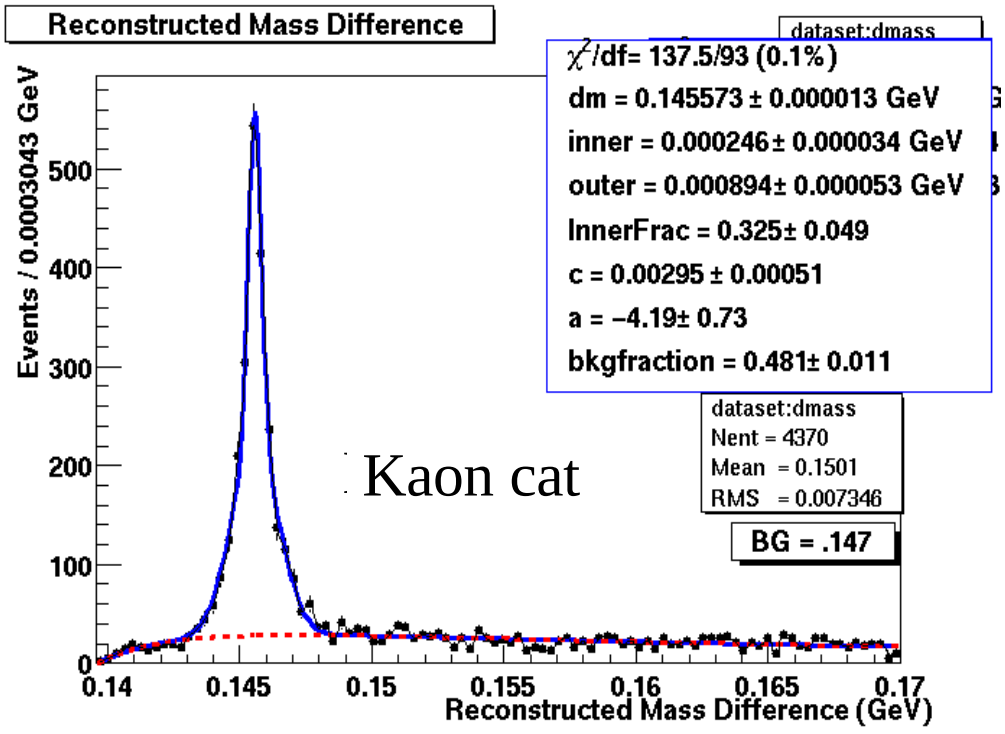
1) Combinatoric − Bad Dstar −either the slow pion is wrong or one of the D0 daughters is wrong
2) Fake Lepton − Good Dstar, bad lepton.
3) Uncorrelated/Cascade Lepton − Good Dstar, good lepton but they don't form a real B0
4) CCbar − these events can produce a Dstar and lepton in a back to back configuration
5) Charged Bs − can produce D*lν through a D** resonance.

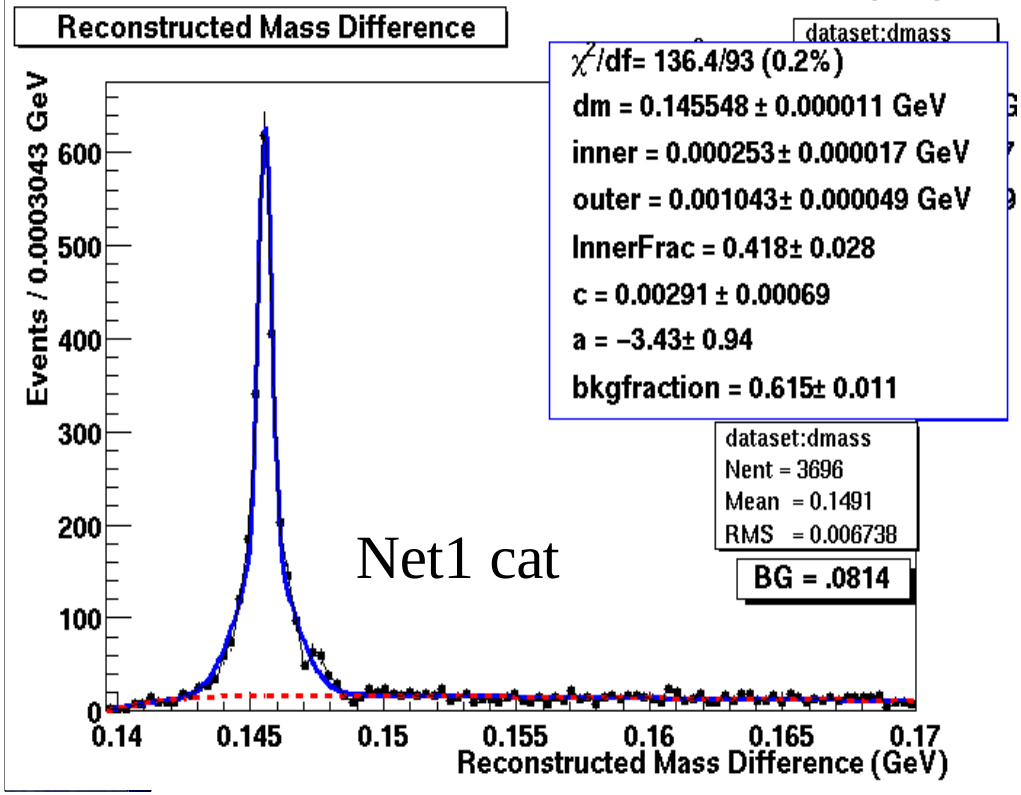
Combinatoric Backgrounds

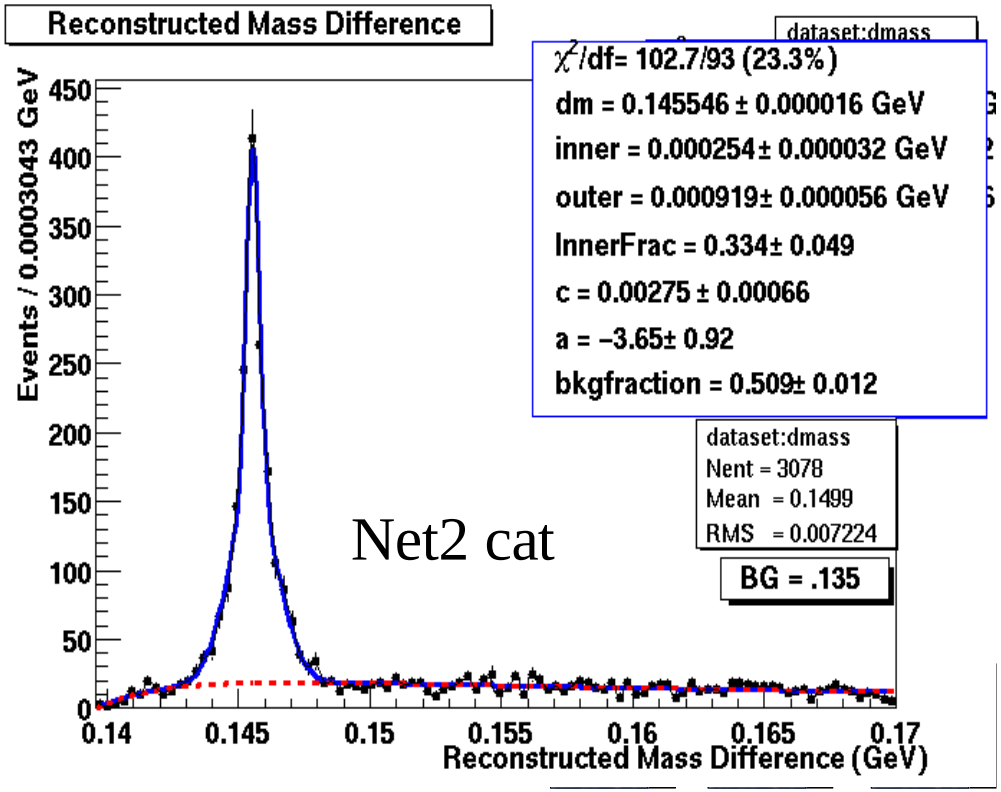
The signal is fitted as a double Gaussian, the background is fitted as $(1-\exp((m-m_{pion})/c))*(m-m_{pion})^{a}$.

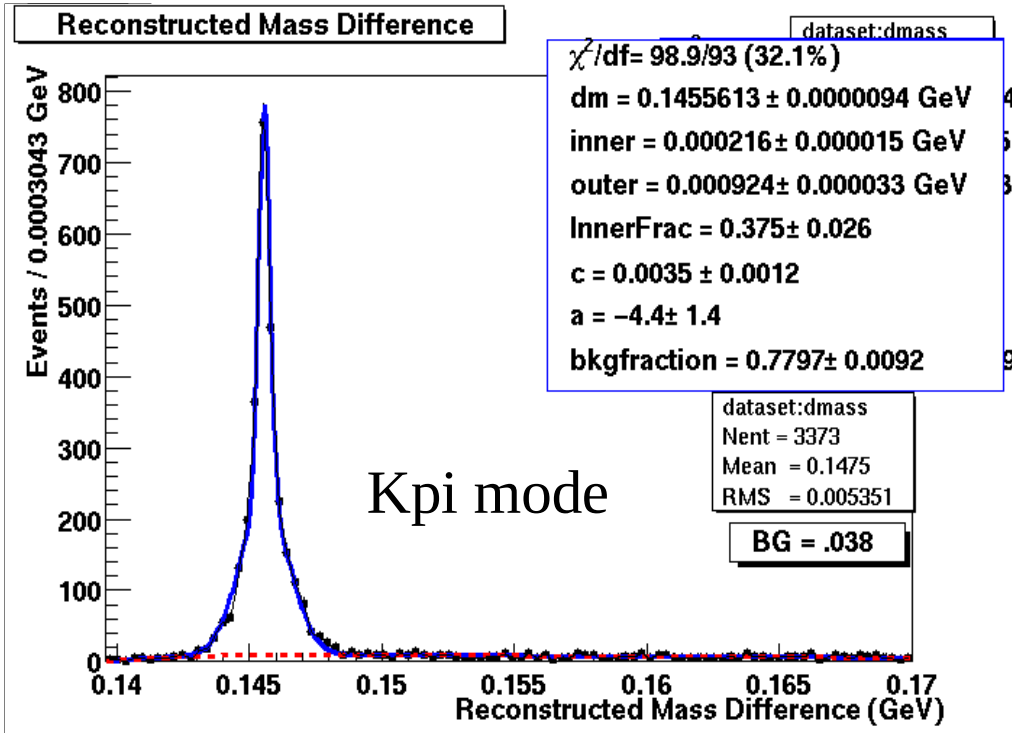


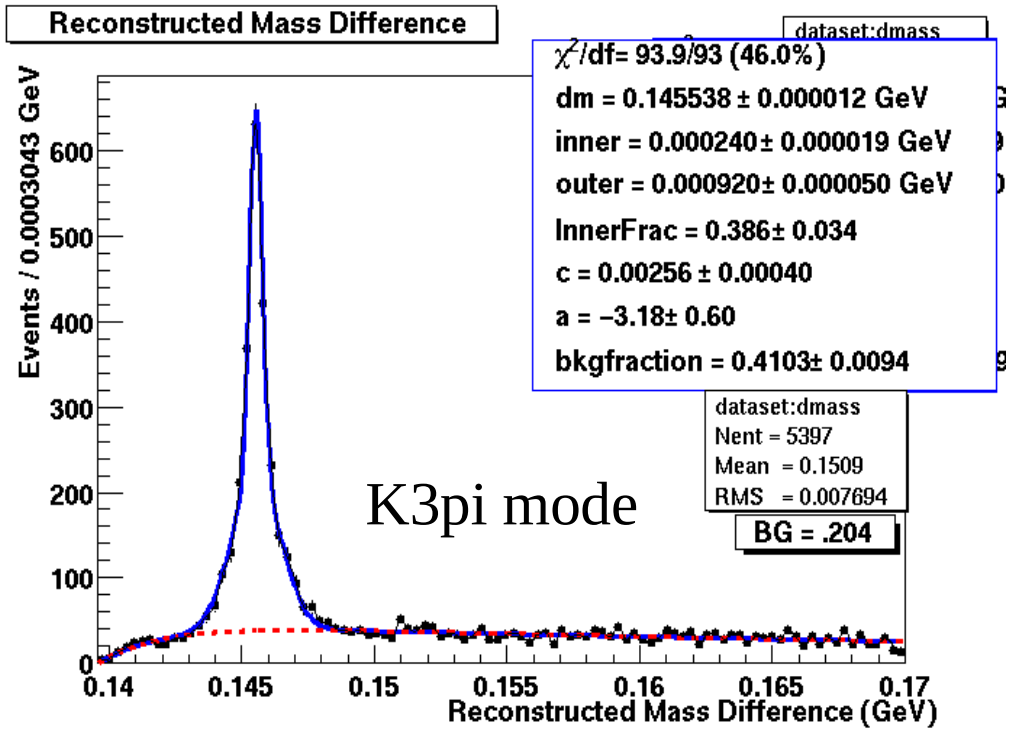

Reconstructed Mass Difference
dataset:dmass
χ²/df= 88.8/93 (60.5%)
dm = 0.145572 ± 0.000015 GeV
inner = 0.000256± 0.000022 GeV
outer = 0.000998± 0.000063 GeV
InnerFrac = 0.437± 0.040
c = 0.0032 ± 0.0013
a = −6.5± 1.8
bkgfraction = 0.750± 0.014
dataset:dmass
Nent = 1719
Mean = 0.1476
RMS = 0.005332
BG = .057
Lepton cat
Events / 0.0003043 GeV
Reconstructed Mass Difference (GeV)

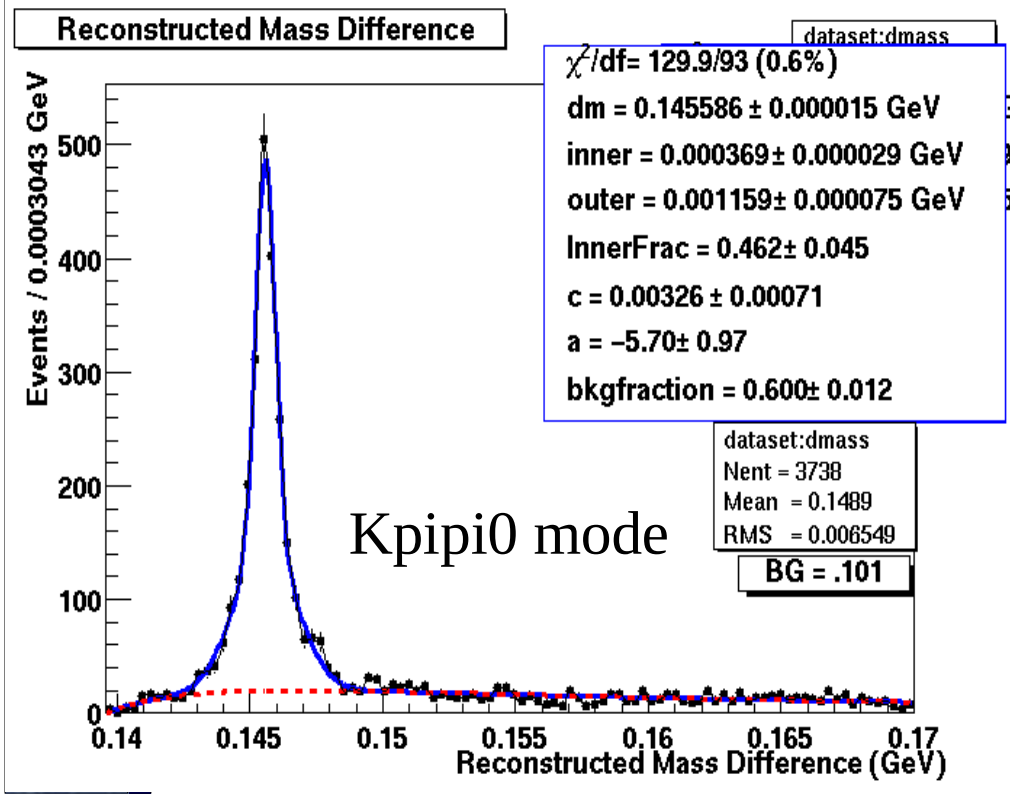

Reconstructed Mass Difference
dataset:dmass
χ²/df= 137.5/93 (0.1%)
dm = 0.145573 ± 0.000013 GeV
inner = 0.000246± 0.000034 GeV
outer = 0.000894± 0.000053 GeV
InnerFrac = 0.325± 0.049
c = 0.00295 ± 0.00051
a = −4.19± 0.73
bkgfraction = 0.481± 0.011
dataset:dmass
Nent = 4370
Mean = 0.1501
RMS = 0.007346
BG = .147
Kaon cat
Events / 0.0003043 GeV
Reconstructed Mass Difference (GeV)

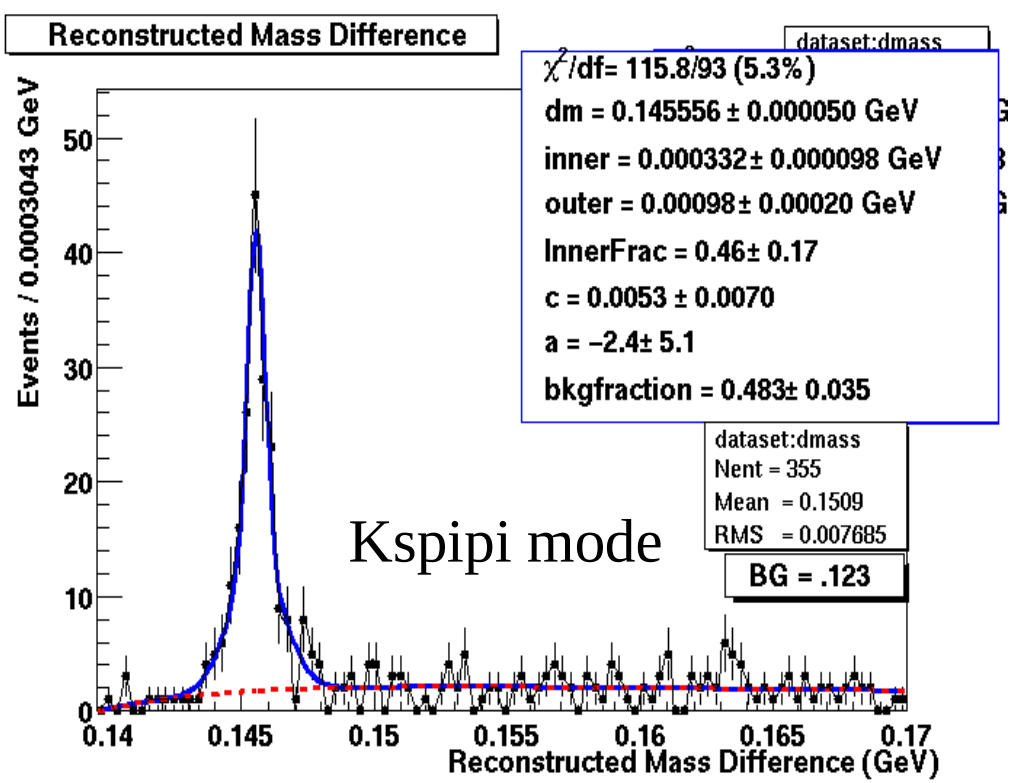

Reconstructed Mass Difference
dataset:dmass
χ²/df= 136.4/93 (0.2%)
dm = 0.145548 ± 0.000011 GeV
inner = 0.000253± 0.000017 GeV
outer = 0.001043± 0.000049 GeV
InnerFrac = 0.418± 0.028
c = 0.00291 ± 0.00069
a = −3.43± 0.94
bkgfraction = 0.615± 0.011
dataset:dmass
Nent = 3696
Mean = 0.1491
RMS = 0.006738
BG = .0814
Net1 cat
Events / 0.0003043 GeV
Reconstructed Mass Difference (GeV)


Reconstructed Mass Difference
dataset:dmass
χ²/df= 102.7/93 (23.3%)
dm = 0.145546 ± 0.000016 GeV
inner = 0.000254± 0.000032 GeV
outer = 0.000919± 0.000056 GeV
InnerFrac = 0.334± 0.049
c = 0.00275 ± 0.00066
a = −3.65± 0.92
bkgfraction = 0.509± 0.012
dataset:dmass
Nent = 3078
Mean = 0.1499
RMS = 0.007224
BG = .135
Net2 cat
Events / 0.0003043 GeV
Reconstructed Mass Difference (GeV)


Reconstructed Mass Difference
dataset:dmass
χ²/df= 98.9/93 (32.1%)
dm = 0.1455613 ± 0.0000094 GeV
inner = 0.000216± 0.000015 GeV
outer = 0.000924± 0.000033 GeV
InnerFrac = 0.375± 0.026
c = 0.0035 ± 0.0012
a = −4.4± 1.4
bkgfraction = 0.7797± 0.0092
dataset:dmass
Nent = 3373
Mean = 0.1475
RMS = 0.005351
BG = .038
Kpi mode
Events / 0.0003043 GeV
Reconstructed Mass Difference (GeV)


Reconstructed Mass Difference
dataset:dmass
χ²/df= 93.9/93 (46.0%)
dm = 0.145538 ± 0.000012 GeV
inner = 0.000240± 0.000019 GeV
outer = 0.000920± 0.000050 GeV
InnerFrac = 0.386± 0.034
c = 0.00256 ± 0.00040
a = −3.18± 0.60
bkgfraction = 0.4103± 0.0094
dataset:dmass
Nent = 5397
Mean = 0.1509
RMS = 0.007694
BG = .204
K3pi mode
Events / 0.0003043 GeV
Reconstructed Mass Difference (GeV)

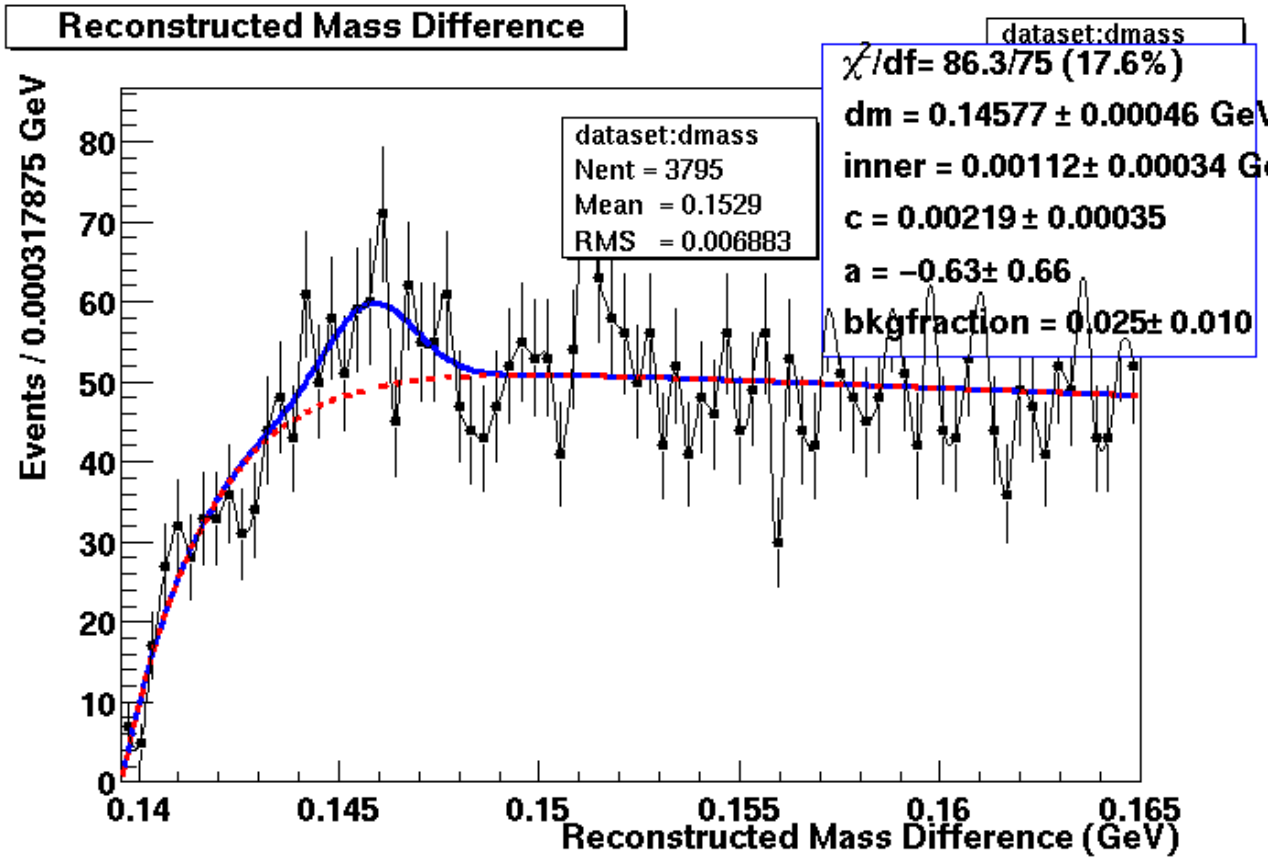

Reconstructed Mass Difference
dataset:dmass
χ²/df= 129.9/93 (0.6%)
dm = 0.145586 ± 0.000015 GeV
inner = 0.000369± 0.000029 GeV
outer = 0.001159± 0.000075 GeV
InnerFrac = 0.462± 0.045
c = 0.00326 ± 0.00071
a = −5.70± 0.97
bkgfraction = 0.600± 0.012
dataset:dmass
Nent = 3738
Mean = 0.1489
RMS = 0.006549
BG = .101
Kpipi0 mode
Events / 0.0003043 GeV
Reconstructed Mass Difference (GeV)


Reconstructed Mass Difference
dataset:dmass
χ²/df= 115.8/93 (5.3%)
dm = 0.145556 ± 0.000050 GeV
inner = 0.000332± 0.000098 GeV
outer = 0.00098± 0.00020 GeV
InnerFrac = 0.46± 0.17
c = 0.0053 ± 0.0070
a = −2.4± 5.1
bkgfraction = 0.483± 0.035
dataset:dmass
Nent = 355
Mean = 0.1509
RMS = 0.007685
BG = .123
Kspipi mode
Events / 0.0003043 GeV
Reconstructed Mass Difference (GeV)

Calculated vs MC truth background fractions

	Lepton	Kaon	Net1	Net2	Kpi	K3pi	Kpipi0	Kspipi
Inner fraction	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Outer fraction	0.955	0.975	0.945	0.971	0.970	0.970	0.916	0.959
Events in Window	1331	2424	2395	1776	2683	2669	2383	191
Signal Events	1256	2067	2200	1537	2580	2174	2142	168
Back Fraction	0.057	0.147	0.081	0.135	0.038	0.186	0.101	0.123
Error on fraction	0.007	0.008	0.006	0.009	0.004	0.008	0.007	0.026
––––––––––								
MC events	1243	2019	2118	1514	2581	2125	2028	160
MC back fraction	0.066	0.167	0.116	0.148	0.038	0.204	0.149	0.162
Error on fraction	0.007	0.008	0.007	0.009	0.004	0.009	0.008	0.029

Peaking in the Combinatoric Background



Optimize D*–D0 window cut

Results for $S^2/(S+N)$ for various signal window widths

	All tag cat	Lepton	Kaon	Net1	Net2
1.50	5761.4	1087.2	1636.7	1822.7	1219.2
1.60	5822.4	1096.2	1651.9	1852.2	1227.1
1.70	5877.4	1112.5	1658.0	1881.6	1232.9
1.80	5922.0	1118.3	**1666.6**	1909.8	1236.7
1.90	5932.0	1125.8	1661.8	1916.8	**1239.1**
2.00	**5935.6**	1131.9	1661.0	1919.1	1237.0
2.10	5932.9	1134.3	1653.5	**1923.1**	1237.7
2.20	5920.4	1139.6	1645.1	1919.5	1234.5
2.30	5908.5	**1142.9**	1635.7	1921.2	1230.0
2.40	5879.5	1142.7	1627.4	1909.3	1223.2
2.50	5858.4	1139.4	1619.8	1906.2	1218.0

Fake Lepton

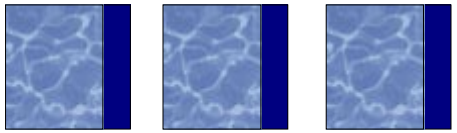
We assume that the fakes have the same time distribution as D*l candidates that fail Lepton ID. We calculate the lepton fake rate using the following equations:

N(pass eid) = VtElectron*N(e) + VtFakeElectron(fake)

N(pass muid) = VtMuon*N(mu) + VtFakeMuon(fake)

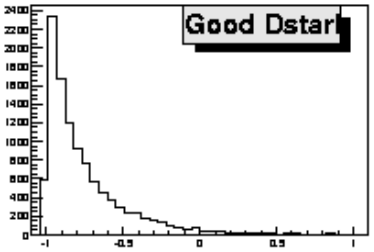
N(fail id) = (1−LElectron)*N(e) + (1−LMuon)*N(mu) +

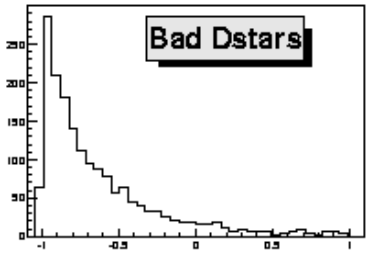
(1−LFakeElectron−LFakeMuon)*N(fake)

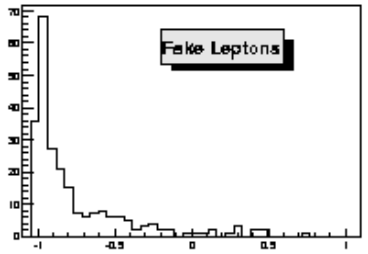


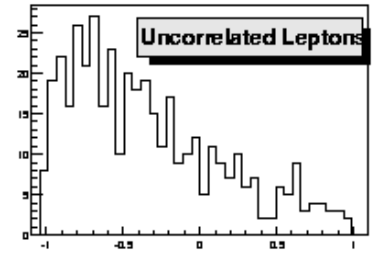
Different failure modes of D*l's

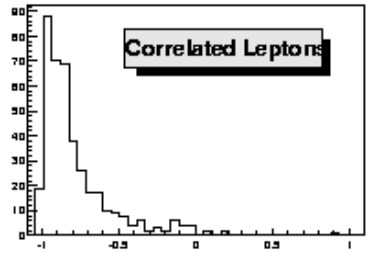
All cuts except cos(D*l) are applied

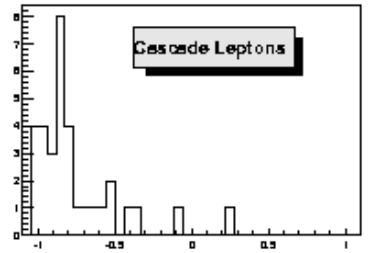


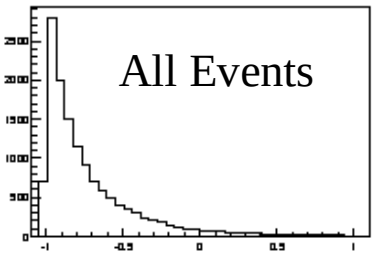












Uncorrelated/Cascade Leptons

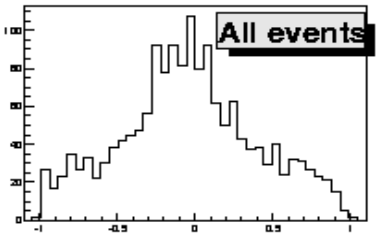
Uncorrelated leptons come from the other B0 and should have no angular correlation with our real D* (until we make our angular cuts).

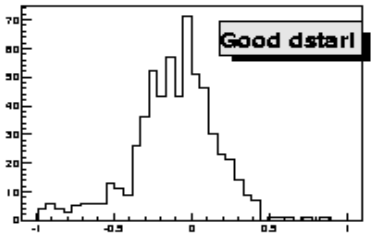
Cascade leptons should be mostly eliminated by the high lepton momentum cut.

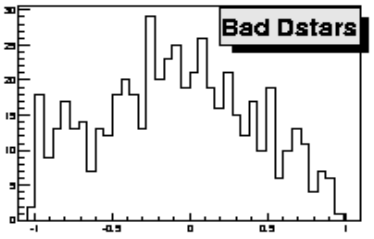
	All Cuts	Good D*l	Bad D*	Fake	Correlated	Uncorrelated	Cascade
All cos(D*l)	12200	9843	1348	218	379	382	30
cos(D*l)<0	11726	9561	1255	207	374	300	29
cos(D*l)>0	474	282	93	11	5	82	1

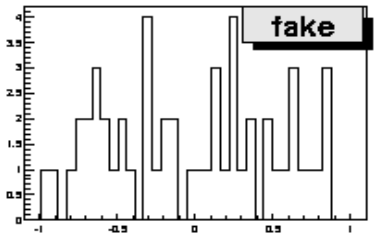
cos(D*l) in flip lepton sample

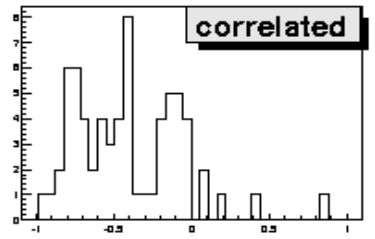
All standard cuts applied except cos(D*l) and cosBYflip vice cosBY

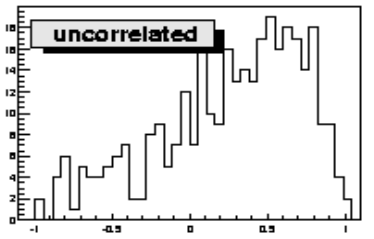


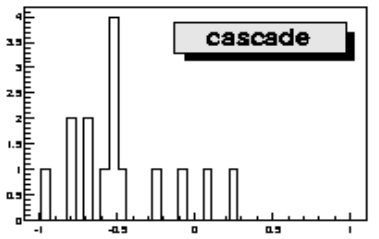












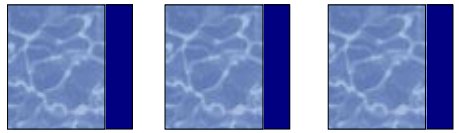
Flip Lepton optimization of cos(D*l) cut

cos(D*l)	S2/(S+B)	Unassociated Lepton fraction	# Unassociated Lepton Events
0.00	58.7	0.402	146
0.05	63.9	0.441	145
0.10	67.8	0.498	136
0.15	67.9	0.527	129
0.20	68.8	0.559	123
0.25	69.4	0.598	116
0.30	**70.8**	**0.643**	**110**
0.35	68.0	0.667	102
0.40	65.4	0.688	95
0.45	63.4	0.712	89
0.50	52.8	0.701	75

CC bar

CCbar estimates are made from offpeak data

1. Run code on offpeak data
2. Run code over Monte Carlo ccbar events
3. Verify MC matches, use MC to get idea of amounts of fake lepton, combinatoric backgrounds in offpeak data



Charged Bs

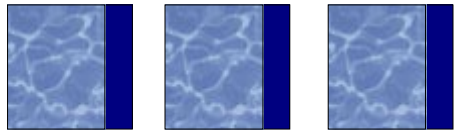
Charged Bs are devious. They can decay like:

B+ −> D**lν, D**−>D* + n soft pions

"soft pion" = very low momentum pion

We can easily find a real D* vertexing with a soft pion and lepton (a good D*l candidate) and all we missed was an extra soft pion which has no detectable effects.

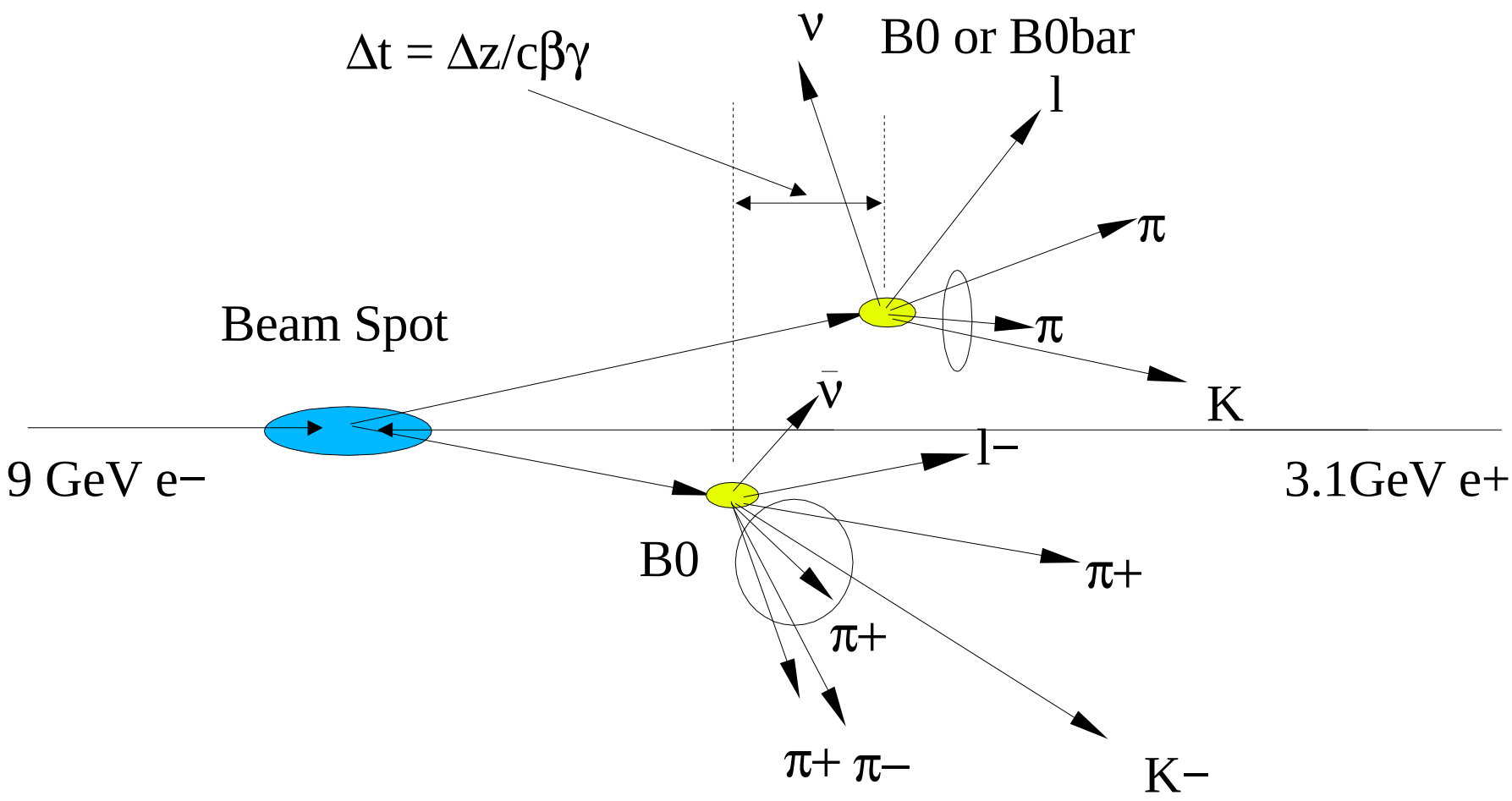
This background fraction floats and is fitted for.



Minor backgrounds

1) uds – no Monte Carlo uds events pass our cuts.
2) These events would be taken care of by the offpeak data if they did pass our cuts.

Tagging



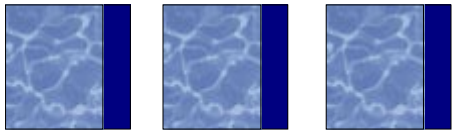
4 Fitting for Δm

1. I am using an unbinned maximum likelihood fit, based on Δt, Δt_error and mixing status
    1. Uses Probability Distribution Functions(PDFs)
    2. Signal and backgrounds are built up from basic building blocks.
    3. PDFs used for analysis:
        1. Dstar background
        2. Blifetime (zero and non−zero lifetimes)
        3. Mixed and unmixed B0 decay
        4. Triple Gaussian resolution function

Fitting for background

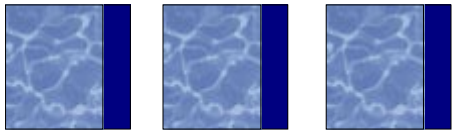
For each background:

1. Fit for background fraction
2. Fit sideband data for three types of time structure (convoluted with a resolution function)
    1. A prompt component with zero life time
    2. A B lifetime component
    3. A B lifetime component with mixing



Final Fit

1. Fix all the background parameters to their fitted values, including resolution function parameters.
2. Fit for a B lifetime with mixing component + B lifetime without mixing + fixed backgrounds (Blifetimes are allowed to float).
3. Fraction of with mixing/without mixing gives a measurement of B+ background.



List of fit parameters

1) Universal parameters
    1) "zero" – used for prompt lifetime, zero frequency
    2) 3 outlier parameters for background pdfs
2) Backgrounds (x3)
    1) 5 more resolution parameters for triple gaussian
    2) 6 "physics" – dm, tau, w, p frac, B+ frac, back frac
3) Signal
    1) 8 resolution parameters (frac, width outlier fixed)
    2) 6 "physics" – dm, tau, w, tauB+, wB+,B+ frac
        1) WB+ fixed from MC truth, all others float
4) Totals: 51 parameters, 11 float in final fit

Fit values

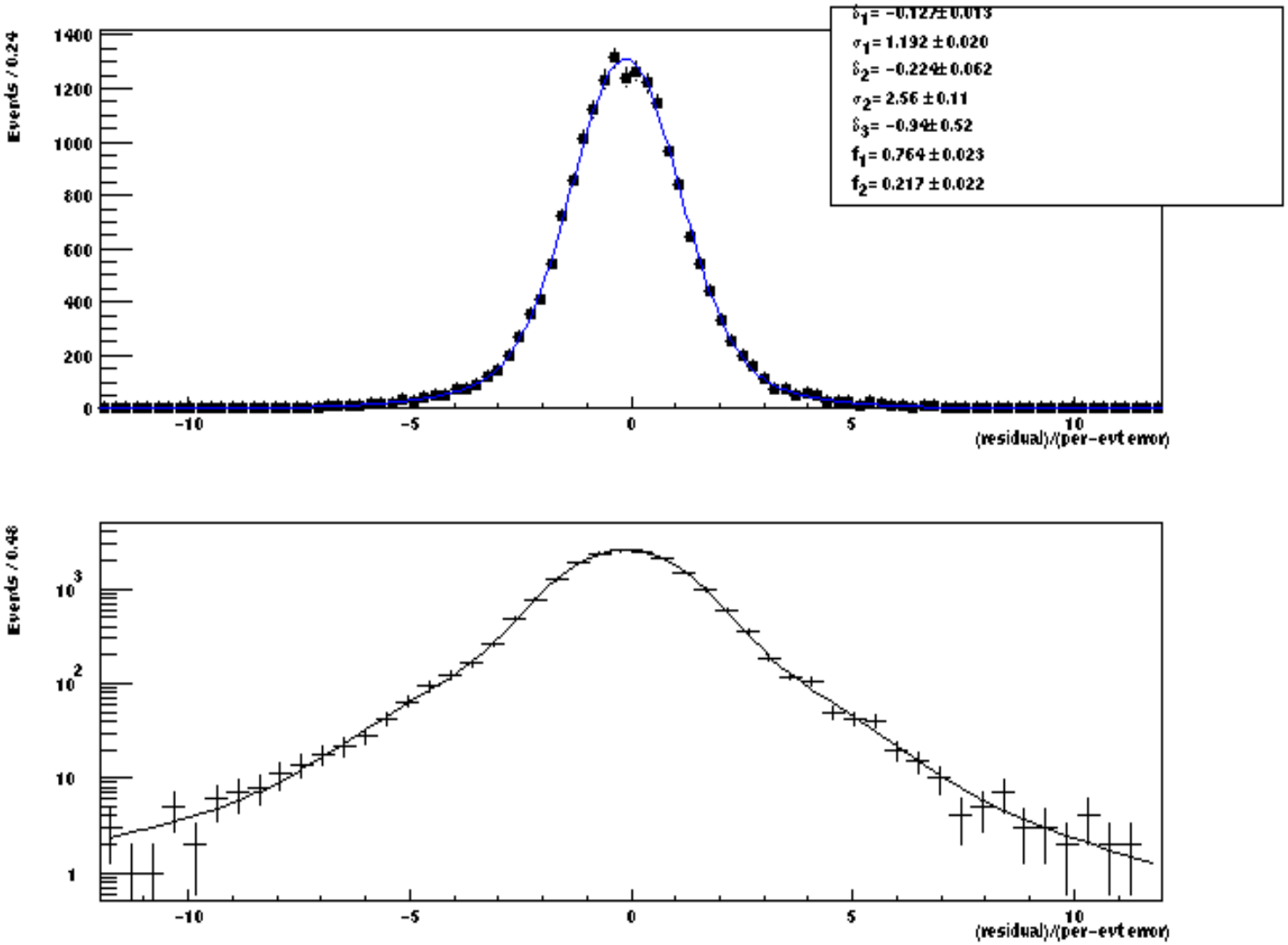
Here are the fit values, several issues are present which need to be readdressed

- Signal outlier bias, Flip lepton sample, B+ fraction

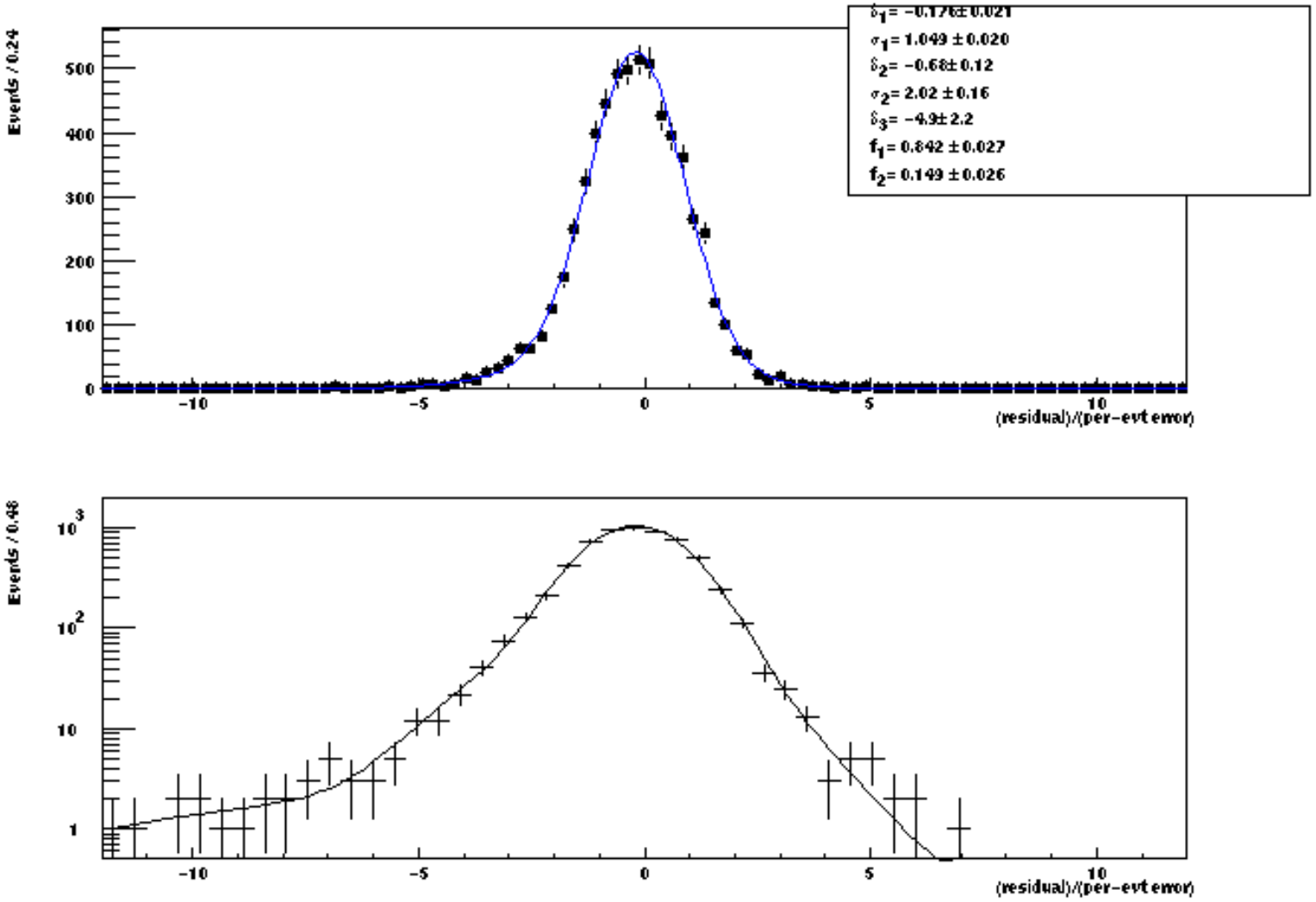
MC generated with $\Delta m = .472\ ps^{-1}$, $\tau = 1.548$ ps

	Lepton	Kaon	Net1	Net2	Combined
Δm	.446 +/− .031	.426 +/− .051	.482 +/− .033	.488 +/− .152	.459+/−.020
τ	1.593 +/− .081	1.548 +/− .358	1.59 +/− .387	1.76 +/− .237	1.62+/−.074
w	.055 +/− .018	.210 +/− .060	.096 +/− .025	.311 +/− .041	
MC truth w	.056 +/− .007	.212 +/− .010	.124 +/− .007	.336 +/− .014	
B+ fraction	.25 +/− .15	.001 +/− .15	.034 +/− .18	.35 +/− .32	
MC truth B+	.049 +/− .0062	.086 +/− .0061	.073 +/− .0056	.065 +/− .0062	

Pull distribution for background events

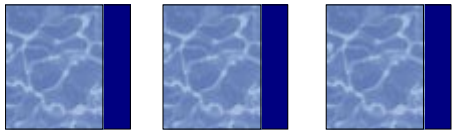


Pull distribution for signal events



To Do List

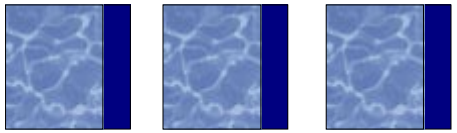
1) Add ccbar component for off−peak data
2) Work on isolating the "flip lepton" part of flip lepton sample.
3) Add blinding strings to RooFitTools macros so I can work "blind" on data.
4) Look at outliers in more detail
5) Produce list of systematics and cross checks to be done, complete checks.
6) Write BAD note documentation



Systematics and Cross Checks

Systematics

1) MC generic & signal
2) Resolution function
3) B lifetime
4) Z Scale, boost
5) Beam position
6) Background Dt
7) Background Res function
8) Background fractions
9) Beamspot Position
10) Dilutions
11) SVT Alignment

Cross Checks

1) B0 vs B0bar
2) D0 decay mode
3) Tagging category
4) Different Resolution Models
5) B lifetime studies
6) Dataset